APPENDIX 1
INTEGRATED PEST MANAGEMENT

(This appendix was adapted from Module 3 of Nutrient and Pest Management Considerations in a Conservation Management System Plan, NRCS National Employee Development Center self-paced study course, 1999.)

What is a pest?

A pest is any organism (plant or animal) that causes trouble, annoyance, or discomfort or becomes a nuisance by destroying food and fiber products, causing structural damage, or creating a poor environment for other organisms. Ecologically speaking, no organism is born a pest; it all depends on human perspective.

Major pests of agricultural and horticultural crops

Insects and related arthropods—Invertebrate animals, such as caterpillars, true bugs, beetles, and mites that cause injury by feeding on plants and animals or by transmitting pathogens that cause diseases.

Nematodes—Microscopic, multi-cellular, unsegmented roundworms that parasitize animals and plants. Most nematodes that attack agricultural crops feed on the roots, but a few feed aboveground on inside stems and leaves.

Pathogens—Disease causing bacteria, fungi, viruses, and related organisms. Note that a pathogen is the agent whose injury causes a disease, whereas a disease is the process of injury that the pathogen causes.
Most pathogens are too small to be seen with the naked eye, while diseases manifest themselves visually as symptoms and signs.

Vertebrates—Any native or introduced, wild or feral, nonhuman species of vertebrate animal that is detrimental to one or more persons as a health hazard or general nuisance, or by destroying food, fiber, or natural resources. Vertebrate feeding in agricultural crops causes the majority of direct damage including animals, such as mice, rats, and birds. Vertebrates may also cause damage indirectly by transmitting human diseases.

Weeds—Undesirable plants or plants in undesirable locations that reduce crop yield and quality by competing for space, water, and nutrients; weeds also may harbor crop attacking insects and pathogens.

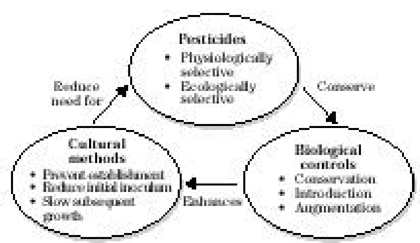
Weeds also include plants that interfere with other human activities, such as by prolifically growing in waterways, or those that cause discomfort, such as skin irritation or hay fever.

Integrated pest management defined

Integrated pest management is an approach to pest control that combines biological, cultural, and other alternatives to chemical control with the judicious use of pesticides. The objective of IPM is to maintain pest levels below economically damaging levels while minimizing harmful effects of pest control on human health and environmental resources. Figure 2 -1 shows a model for IPM. Pest problems do not arise as independent or isolated events. Crops and pests are part of an agroecosystem, and they are governed by the same biological processes as those in natural ecosystems. Attempts to control one pest species without regard for the entire ecosystem can disrupt checks and balances between crop plants, pests, beneficials, and the physical environment. Failure to appreciate ecological interactions may increase the severity of pest infestations.

Action taken against one pest may exacerbate problems with another or may be incompatible with other control tactics. Integrated pest management (IPM) depends on a detailed understanding of pests natural enemies and crop growth and development, and in particular, what causes outbreaks and determines survival.

Figure 2-1 Conceptual model for integrated pest management showing how control tactics are integrated into a complementary system



Integrated means that a broad interdisciplinary approach is taken using scientific principles of plant protection to bring together a variety of management tactics into an overall strategy.

IPM strives for maximum use of naturally occurring control forces in the pest's environment including weather, pest diseases, predators, and parasites (fig.2 -2).

Bio-intensive IPM attempts to reduce the use of conventional pesticides by looking first to biological and cultural alternatives as well as use of least toxic bio-rational (derived from items in nature) products that only affect the target pest.

With IPM, the role for chemical pesticides is one of last resort if other alternatives fail to correct the problem. Foliar applied pesticides are rarely applied according to a pre-set schedule or spray calendar in an IPM program. Instead, they only are used if scouting shows they really are needed to prevent severe damage (fig 2 -3).

Prescriptive IPM depends largely on judicious use of pesticides based on field scouting that shows pest infestation has exceeded economic thresholds.

Management refers to the decision making process and practices used to keep pest numbers below economical threshold levels. Eradication is rarely the goal because low levels of pest are tolerable from an economic point of view. The essence of IPM is decision making: determining if, when, where, and what mix of control methods are needed. Diverse IPM strategies help to control pest resistance, pest resurgence, and pest replacement. IPM also helps to control pest resistance, pest resurgence, and pest replacement.

Resistance is the innate (genetically inherited) ability of organisms to evolve or select for strains that can survive exposure to pesticides formerly lethal to earlier generations. Resistance can develop when pesticides kill susceptible individuals while allowing naturally resistant individuals to survive. These survivors pass to their offspring the genetically determined resistance trait. With repeated pesticide application, the pest population increasingly is comprised of resistant individuals.

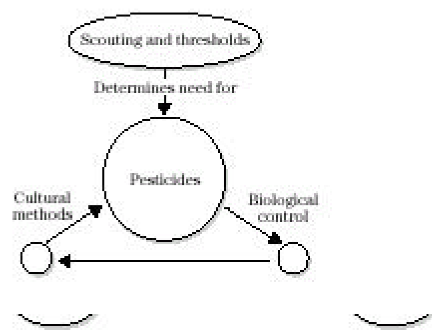
In theory, pests can develop resistance to any type of IPM tactic: biological, cultural, or chemical.

In the Midwest, farmers routinely rotate corn with soybeans to break the infestation cycle of the corn rootworm, an insect that only feeds on grassy plants and so has become the key insect pest of field corn.

Yet the rootworm has developed strains that overcome crop rotation by extending their overwintering resting stage in the soil from one winter to several winters. This allows them to be ready to attack corn the next time it is planted in the field.

Still other rootworm populations have developed strains that feed on both corn and soybeans.

Figure 2-3 Prescriptive IPM

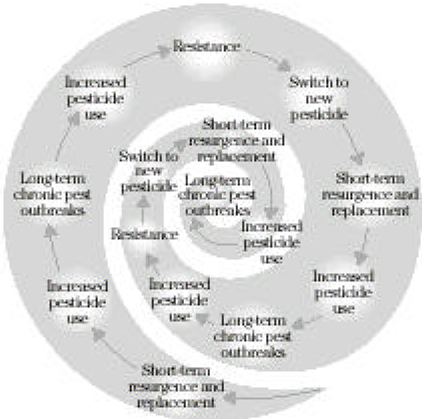


In practice, resistance occurs most frequently in response to pesticide use. Insects were the first group of pests to develop pesticide resistant strains. World wide, over 600 species, are resistant to at least one insecticide; some are resistant to all the major classes of insecticides. Herbicide resistant weeds now number more than 100 worldwide and fungicide resistant plant pathogens have also been observed.

Resurgence is the situation where insecticide application initially reduces an infestation, but soon afterwards the pest rebounds (resurges) to higher levels than before treatment.

Replacement, or secondary pest outbreak, is resurgence of nontarget pests. It occurs when a pesticide is used to control the target pest, but afterwards a formerly insignificant pest replaces the target pest as an economic problem. Figure 2 -5 illustrates the treadmill effect of over-reliance on pesticides.

Figure 2- 5 Pesticide treadmill where over-reliance on pesticides creates an ever-increasing need to use pesticides



IPM principles

Principle #1. There is no silver bullet, use several complimentary control practices to increase the long term stability of the production system.

Over reliance on any single control measure can have undesirable effects. This especially has been documented for pesticides where over-reliance can lead to the "3-R's": resistance, resurgence, and replacement. IPM considers all possible control actions, including taking no action at all, and fits tactics together into mutually complementary strategies. The idea is to combine different control tactics into an overall strategy that balances the strengths of each against any individual weaknesses.

Principle #2. Tolerate low numbers of pests.

IPM recognizes that keeping fields entirely pest-free is neither necessary nor desirable; it is not necessary to totally eliminate pests and, in fact, low levels of pest help maintain a predator population. Because most crops can tolerate low pest infestation levels without any loss in harvestable produce or quality, the presence of a pest does not necessarily mean that you have a pest problem. IPM seeks to reduce pest populations below levels that are economically damaging rather than to totally eliminate infestations.

Principle #3. Treat the causes of pest out-breaks, not the symptoms.

IPM requires detailed understanding of pest biology and ecology so that the cropping system can be manipulated to the pest's disadvantage.

The idea is to make the crop less favorable for pest survival and reproduction with as little disturbance to the rest of the ecosystem as possible.

Principle #4. If you kill the natural enemies, you inherit their job.

Naturally occurring predators, parasites, pathogens, antagonists, and competitors (collectively known as biological control agents) help keep many pest populations in check. IPM strives to enhance the impact of beneficials and other natural controls by conserving or augmenting those agents already present.

Principle #5. Pesticides are not a substitute for good farming.

A vigorously growing plant can better defend itself against pests than a weak, stressed plant. IPM takes maximum advantage of farming practices that promote plant health and allow crops to escape or tolerate pest injury. IPM begins from the premise that killing pests is not the objective; protecting the commodity is. Pest status can be reduced by repelling the pest, avoiding the pest, or reducing its rate of colonization or invasion, as well as by directly killing the pest.

Overview of pest management Practices

Producers put IPM philosophy into practice by following these three steps:

Step 1. Use cultural methods, biological controls, and other alternatives to conventional chemical pesticides as the basis of the IPM program.

Step 2. Use quantifiable field scouting, pest forecasting, and economic thresholds to ensure that pesticides are used only when there are real pest problems.

Step 3. Select pesticides that are efficacious, cost effective and least likely to disrupt natural and biological controls. Match pesticides with field site features so that the risk of contaminating water is minimized.

Alternatives to pesticides

Cultural methods

Cultural methods are those farming practices that control pests mechanically or break their infestation cycle by making the living and non-living environment less suitable for pest survival by:

Tillage

Mowing

Vacuuming

Burning

Reducing the overall favorableness of the habitat (by destroying pest over-wintering sites and other infestation sources both in the crop field and alternate hosts or habitats)

Altering planting patterns to disrupt or interrupt in time and space the food or other habitat resources required by the pest

Diverting mobile pests from the crop

Enhancing the vigor of the crop so that it can better tolerate pest injury

Examples of cultural controls used in IPM programs include:

Crop rotation

Tillage operations that turn the soil and bury crop debris

Altering planting and harvest dates

Altering seeding rates and crop spacing

Seedbed preparation, fertilizer application, and irrigation schedules that maintain plant vigor and help plants outgrow pests

Sanitation practices such as cleaning tillage harvesting equipment

Certified seed that is free of pathogens and seed

Cover crops

Trap crops

Pest resistant varieties that can tolerate pest injury, be less attractive to pests, or control by producing chemicals that are toxic to them.

Biological controls

Biological controls use living organisms (natural enemies) to suppress populations of other pests.

Examples are:

Predators are free-living animals (most often other insects or arthropods, but also birds, reptiles, and mammals) that eat other animals (the prey).

Parasitoids are insect (or related arthropods) parasites of other insects (or other arthropods).

Most parasitoids are tiny wasps and flies. They differ zoologically from true parasites (fleas, lice, or intestinal tapeworms) primarily in that parasitoids kill their host whereas parasites weaken, but seldom kill the host.

Pathogens are disease causing microorganisms including viruses, bacteria, fungi, and nematodes.

Conserving naturally occurring parasites and predators is usually the most effective method of biological control.

Field scouting, pest forecasts, and thresholds

One principle of IPM is that pesticides should be used only when field examination or scouting shows infestations exceed economic thresholds, guidelines that differentiate economically insignificant infestations from intolerable populations (fig 2 -6). Pest scouting should be conducted in each individual field and generally should be random and representative.

The field examination or scouting must provide quantifiable pest/damage counts that can be used in making the management decisions for each individual field. In figure 2 -6, the IPM scout used an understanding of pest biology to divide a large and variable field into three subsections.

The only time to take control action and apply pesticides is when pest density reaches levels near the economic threshold (ET) value.

Pesticide application here keeps infestations from increasing beyond the breakeven economic injury level (EIL) value.

The shaded part of the pest population curve in figure 2 -7 shows actual density while the dotted curve shows a pest population increase in the absence of control.

Figure 2- 6 Pest scouting

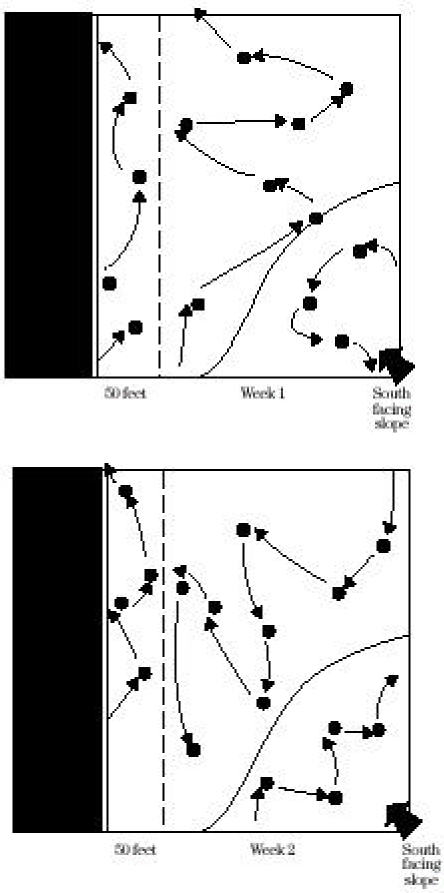
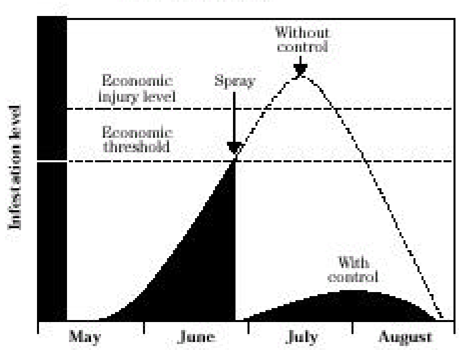


Figure 2- 7 Relationship of economic injury level, economic threshold, and seasonal pest population growth



Site-specific pesticide selection

The final component of IPM is selection of pesticides that are cost effective, least disruptive to the ecosystem and pose the least risk of leaching through soil or being transported from fields in runoff water and sediment or drifting as spray particles on the wind.

Pesticides

Pesticides are defined as ***"any substance used for controlling, preventing, destroying, repelling, or mitigating any pest."*** Tables 2 -1 and 2 -2 show the common pesticide classes and their target pests and functions.

Herbicides, insecticides, and fungicides represent more than 93 percent of the pesticide active ingredient used worldwide. Herbicides typically represent more than 50 percent of pesticide use, followed by insecticides (23 to 35 percent),and fungicides (11 to 14 percent).

Formulations

Most end use pesticide products are not 100 percent active ingredients. Typically, they are diluted with water, oil, air, or chemically inactive (inert) solids so they can be handled by application equipment and spread evenly over the area to be treated. Because the basic chemical generally cannot be added directly to water or mixed in the field with solids, manufacturers must further modify their products by combining them with other material, such as solvents, wetting agents, stickers, powders, or granules. The final product is called a pesticide formulation and is ready either for use as packaged or after being diluted with water or other carriers. Formulation types are:

WP wettable powder

S solutions

F flowable

G granules or granular

D dusts

SP soluble powder

EC emulsifiable concentrate

Adjuvants are chemicals that are added to a pesticide formulation or spray mixture to improve performance and/or safety. Most pesticide formulations contain at least a small percentage of one or more adjuvants.

Wetting agents allow wettable powders to mix with water.

Emulsifiers allow petroleum-based pesticides (ECs) to mix with water.

Invert emulsifiers allow water-based pesticides to mix with petroleum carrier.

Spreaders allow pesticide to form a uniform coating layer over the treated surface.

Stickers allow pesticide to stay on the treated surface for a longer time without being dislodged.

Penetrants allow the pesticide to get through the outer surface to the inside of the treated target.

Foaming agents reduce drift.

Thickeners reduce drift by increasing droplet size.

Safeners reduce the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.

Compatibility agents aid in combining pesticides effectively.

Buffers allow pesticides to be mixed with diluents or other pesticides of different acidity or alkalinity

Antifoaming agents reduce foaming or spray mixtures that require vigorous agitation.

Table 2-1 Common pesticide classes and target pests

Pesticide class	Target pest
Acaricide	Mites
Avicide	Birds (kills or repells)
Bactericide	Bacteria
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects
Larvicide	Larvae (usually mosquito)
Miticide	Mites
Nematicide	Nematodes
Ovicide	Eggs
Rodenticide	Rodents

Table 2-2 Pesticide classes and functions

Pesticide class	Function
Attractants	Attract insects
Chemosterilants	Sterilize insect or pest vertebrates
Defoliants	Remove leaves
Desiccants	Speed drying of plants
Growth regulators	Stimulate or retard growth of plants or insects
Pheromones	Attract insects or vertebrates
Repellents	Repel insects, mites and ticks, or pest vertebrates